IW-700 Inchworm

Encoder

Encoder Interpolator

Dave Pfenning
NASA/GSFC

Actuator Encoder

- glass scales (gratings)
- 62.5 lines/mm
- no reference mark
- outputs an Analog Sin/Cos

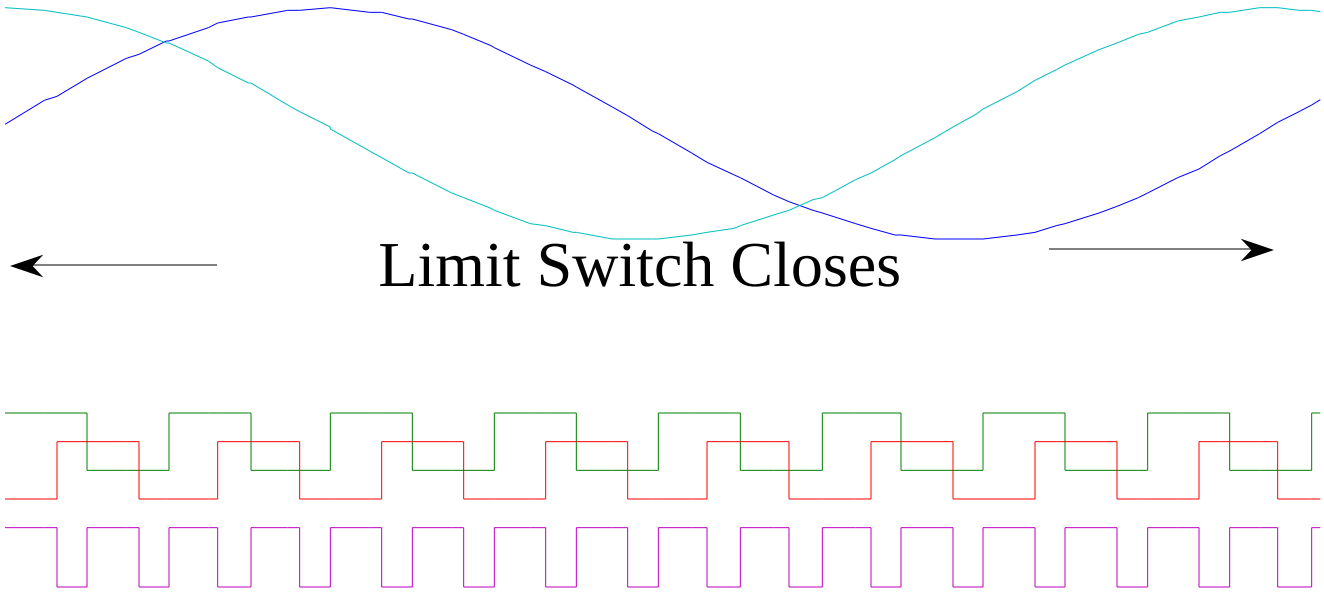
Encoder Interpolator

- currently, Sin/Cos digitized to 3 bits
- 0.5um resolution
- proposed, Sin/Cos digitized to 8 bits
- target resolution 125 nm

Reference Mark

- generate reference mark using the limit switch and output from decoder
- limit switch is accurate to less than16um

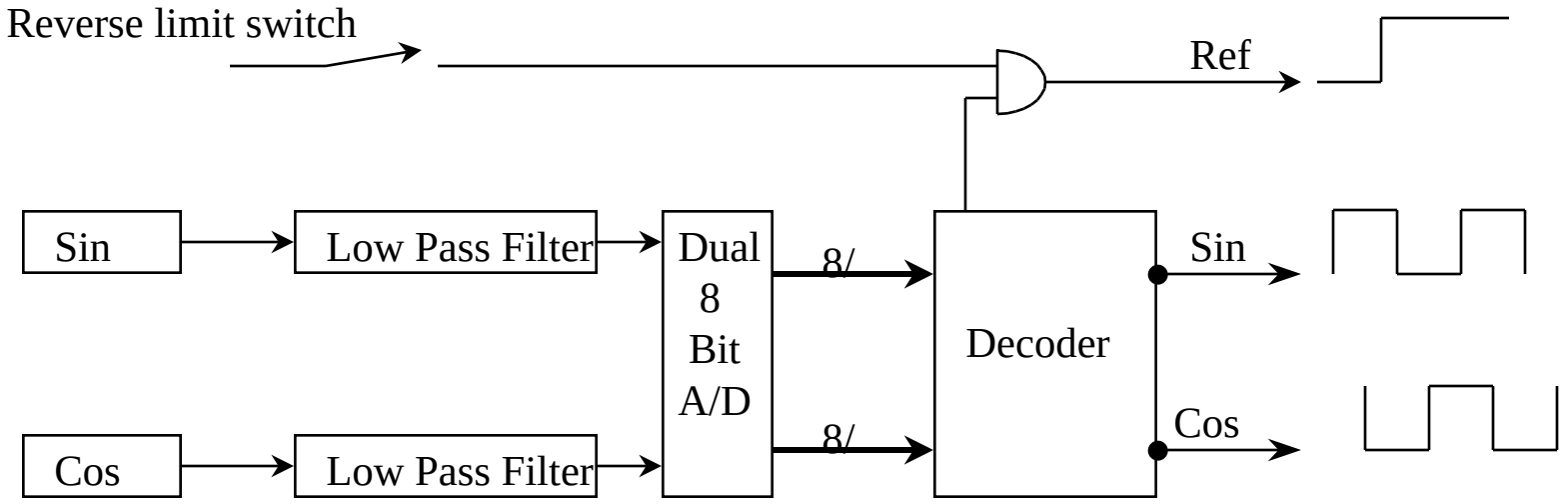
Limit Switch Closure



Reference Mark Generator Block Diagram

The limit switch will always close with in the same 16um period of the encoder scale.Using the limit switch closure and the digitized Sin and Cos position data, it is possible to generate a Reference Mark accurate to the digitized signals.

Reference Mark = limit switch + (sin + cos)



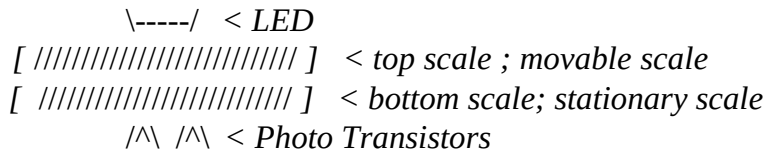
Burleigh Inchworm IW-700

IW-700 Inchworm Motor

The basic resolution of the Inchworm actuator step, as advertised by Burleigh is 4nm. During characterization of the actuators, this number has been in the range of 2.2 to 2.9nm. This number was arrived at by commanding the actuator to take a series of 1000 sub-steps (motor steps). The distance traveled for each series was divided by 1000 to get the average sub-step.

Inchworm Encoder

The encoder used on the IW-700 inchworm consist of two glass scales mounted on top of each other. Each scale has 62.5 lines/mm. The bottom scale is mounted to the actuator housing (stationary scale), the top scale is mounted actuator plunger (movable scale). The light from an LED is focused onto the top scale. There are two phototransistors located below the bottom scale that detect the light from the LED.



As the actuator moves, the light from the LED is intensity modulated when the top scale moves across the bottom scale. The output from the Phototransistors are an Analog SIN and COS with a period equal to 16um (1mm / 62.5).

Current Inchworm Encoder Interpolator

Each SIN and COS are digitized to 3 bits. This results in two square waves. A SIN and COS. Each has 8 cycles (2^3 = 8) for each analog SIN/COS. In the digital world, each of the square waves has two states. One HIGH and One LOW. With eight cycles per one Analog period we now have 16 states. These two square wave SIN and COS are Xored resulting in 32 states. We now have 32 states with a weight of…

16um / 32 = ***0.5um*** *(500nm)*

Purposed Encoder Interpolator

The interpolator currently under development has two possible paths, each resulting in ~125nm resolution. The first will digitize each SIN/COS to 6 bits, using a dual, high speed 6 Bit A/D.
The second approach will use two 8 bit A/D's. The output of the digitizer will go into a decoder that will do the following.

Output a digital Sin and Cos with a target resolution of 125nm, and an output to be anded with the limit switch to produce a Reference Mark. The reference mark will have the accuracy of the target resolution.